Research Proposal on

“To study attention and mental effort in the early brain development of school going children”

Research Guide

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1. Title of research proposal

“To study attention and mental effort in the early brain development of school going children”

2. Introduction

2.1 Early brain development in child

A child's brain develops rapidly during the first five years of life, especially the first three years. It is a time of rapid cognitive, linguistic, social, emotional and motor development. For example, a child learns many words starting at around 15–18 months. Rapid language learning continues into the preschool years.

The child's brain grows as she or he sees, feels, tastes, smells and hears. Each time the child uses one of the senses, a neural connection is made in the child's brain. New experiences repeated many times help make new connections, which shape the way the child thinks, feels, behaves and learns now and in the future.

A close relationship between the child and the caregiver is the best way to nourish the child's growing brain. When a caregiver plays with and sings, speaks, reads or tells a story to the child and nurtures her or him with healthy food, love and affection, the child's brain grows. Being healthy, interacting with caregivers and living in a safe and clean

environment can make a big difference in a child's growth, development and future potential.

Babies need lots of care and affection in the early years. Holding, cuddling and talking to the child stimulate brain growth and promote emotional development. Being kept close to the mother and breastfed on demand provide the infant with a sense of emotional security. The baby suckles for both nutrition and comfort.

For young children, crying is a way of communicating. Responding to the child's cry by holding and/or talking soothingly to her or him will help establish a sense of trust and security.

This kind of early bonding and attachment to the mother, father or other close caregiver helps a child develop a broad range of abilities to use and build upon throughout life. These include the ability to:

- learn
- be self-confident and have high self-esteem
- have positive social skills
- have successful relationships at later ages
- develop a sense of empathy.

As children's brains develop, so do their emotions, which are real and powerful. Children may become frustrated if they are unable to do something or have something they want. They are often frightened of strangers, new situations or the dark. Children whose reactions are laughed at, punished or ignored may grow up shy and unable to express emotions normally. If caregivers are patient and sympathetic when a child expresses strong emotions, the child is more likely to grow up happy, secure and well balanced.

Boys and girls have the same physical, mental, emotional and social needs. Both have the same capacity for learning. Both have the same need for affection, attention and approval.

Young children can experience excessive stress if they are physically or emotionally punished, are exposed to violence, are neglected or abused, or live in families with mental illness, such as depression or substance abuse. These stresses interfere with the developing brain and can lead to cognitive, social and emotional delays and behavior problems in childhood and later in life.

Children who are physically or mentally punished in anger are more likely to become violent themselves. More positive and effective ways to address children's behavior can include:

- providing a child with clear explanations about what to do and what not to do
- responding consistently to certain behaviors
- praising good behavior.

These responses by parents and other caregivers encourage children so they become well-adjusted and productive members of the family and community.

Both parents, as well as other family members, need to be involved in caring and nurturing the growth, learning and development of children. They should make both girls and boys feel equally valued as they encourage them to learn and explore – this is important preparation for school.

Mothers around the world generally take on the primary role of addressing their children's rights and needs. They love, feed, console, teach, play with and care for their children.

A father's role is as vital as the mother's in nurturing and caring for their children and protecting their rights. A father should make daughters and sons feel they are equally important. Just like the mother, the father can help meet their child's needs for love, affection, approval, encouragement and stimulation. Together, the mother and father can ensure that the child receives a quality education and good nutrition and health care.

2.2 What is affective computing?

Affective Computing is computing that relates to, arises from, or deliberately influences emotion or other affective phenomena (Picard, MIT Press 1997).

Emotion is fundamental to human experience, influencing cognition, perception, and everyday tasks such as learning, communication, and even rational decision-making. However, technologists have largely ignored emotion and created an often frustrating experience for people, in part because affect has been misunderstood and hard to measure. Our research develops new technologies and theories that advance basic understanding of affect and its role in children learning experience. We aim to restore a proper balance between emotion and cognition in the design of technologies for addressing child needs during learing process.

Our research will contribute to:

(1) Designing new ways for child to communicate affective-cognitive states, especially by understanding **pupil dilation** in children and calculating **cognitive load**.

(2) Assessing **EEG (electroencephalogram)** parameters of children to assess frustration, stress, and mood indirectly, through natural interaction and conversation;

(3) Pioneering studies examining ethical issues in affective computing.

Affective Computing research combines engineering and computer science with psychology, cognitive science, neuroscience, sociology, education, psychophysiology, value-centered design, ethics, and more. We bring together children with a diversity of technical, artistic, and human abilities in a collaborative spirit to push the boundaries of what can be achieved to improve human affective experience with technology.

2.2 Pupil Dilation

Why do the eye pupils dilate or contract? Is it only a response to change in illumination?Apparently not.It's common knowledge that the eye pupils dilate and contract according to the light they're exposed to. This body mechanism helps regulate the amount of light we receive, which allows us to see better in different light conditions. Our pupils react to visual stimulations, too – a positive or negative response represented in the eyes. Our pupils, involuntary, can dilate or constrict in their size according to whether or not we like what we see.

So what does it mean?

In general, the bigger the eye pupils the more favorable and excited the response. Ourpupils dilate when we see something we like, as if we wish "to grasp" more of what we see. In courtship, for example, it can be a strong signal of affection – prolonged eye contact with dilated pupils is one of the first indicators of attraction. It can be a misleading signal, but more on that later.Not only dilated pupils show a positive response in someone, but we also find them more appealing to look at. That's why babies are 'programmed' to dilate their eye's pupils when looking at adults - they get more affection points.

Toy manufactures, understanding this, produce toys with really big eyes and pupils to draw the attention of kids, who naturally like them better. This also explains why kids (and adults) really like anime character with their excessively big eyes.The opposite is also true, constricted eye pupils show resentment, defiance and general disliking. We also like them less. It's really simple if we think about it – if someone seems not to like you, usually we won't have much incentive to like him or her back.In eye pupils almost every day – when a child is happy about his success we can see his pupils turn to sparkling sphere – he looks full of life! On the other hand, some kids, when being reprimanded, meet my gaze and I can see little defiant needles staring at me.

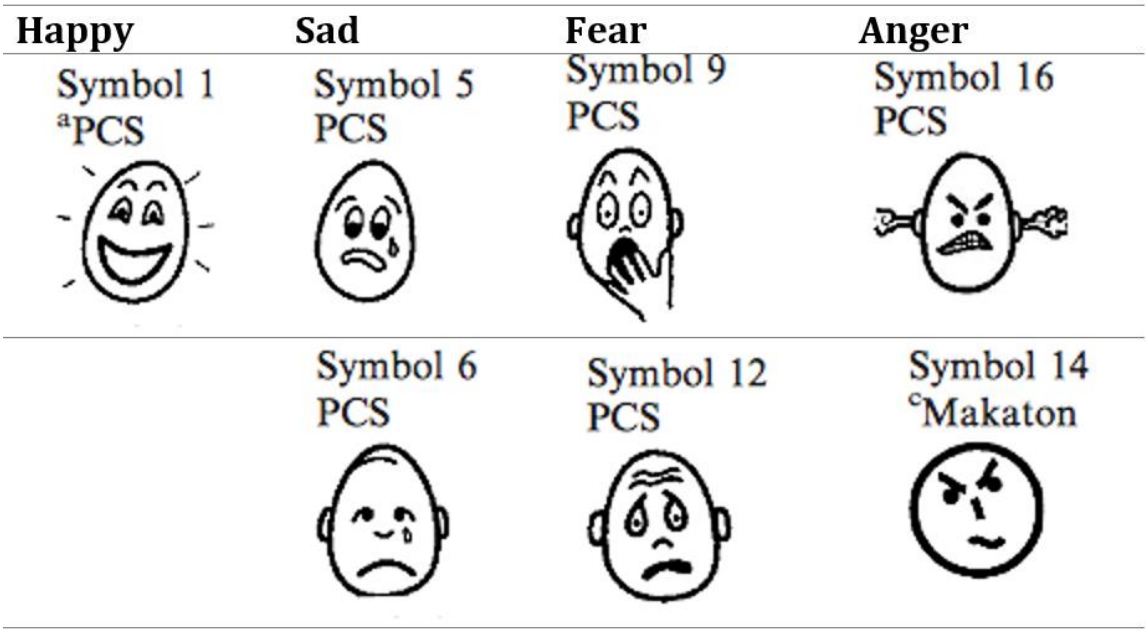


Fig 1: The four best recognizable emotions and their best scoring graphical representation (Visser, Alant, &Harty, 2008).

Cognitive Load

In cognitive psychology, **cognitive load** refers to the total amount of mental effort being used in the working memory. Cognitive load theory was developed out of the study of problem solving by John Sweller in the late 1980s.Sweller argued that instructional design can be used to reduce cognitive load in learners. Cognitive load theory differentiates cognitive load into three types: intrinsic, extraneous, and germane.

Intrinsic cognitive load is the effort associated with a specific topic. Extraneous cognitive load refers to the way information or tasks are presented to a learner. And, germane cognitive load refers to the work put into creating a permanent store of knowledge, or a schema.

Researchers Paas and Van Merriënboer developed a way to measure perceived mental effort which is indicative of cognitive load. Task-invoked pupillary response is a reliable and sensitive measurement of cognitive load that is directly related to working

memory. Heavy cognitive load can have negative effects on task completion, and it is important to note that the experience of cognitive load is not the same in everyone. The elderly, students, and children experience different, and more often higher, amounts of cognitive load.

High cognitive load in the elderly has been shown to affect their center of balance. With increased distractions and cell phone use students are more prone to experiencing high cognitive load which can reduce academic success. Children have less general knowledge than adults which increases their cognitive load. Recent theoretical advances include the incorporation of embodied cognition in order to predict the cognitive load resulting from embodied interactions.

2.3 EEG (electroencephalogram)

What it is

An electroencephalogram (EEG) is a test used to detect abnormalities related to electrical activity of the brain. This procedure tracks and records brain wave patterns. Small metal discs with thin wires (electrodes) are placed on the scalp, and then send signals to a computer to record the results. Normal electrical activity in the brain makes a recognizable pattern. Through an EEG, doctors can look for abnormal patterns that indicate seizures and other problems.

Why It's Done

The most common reason an EEG is performed is to diagnose and monitor seizure disorders. EEGs can also help to identify causes of other problems such as sleep disorders and changes in behavior. EEGs are sometimes used to evaluate brain activity after a severe head injury or before heart or liver transplantation.

Preparation

If our child is having an EEG, preparation is minimal. Our child's hair should be clean and free of oils, sprays, and conditioner to help the electrodes stick to the scalp.

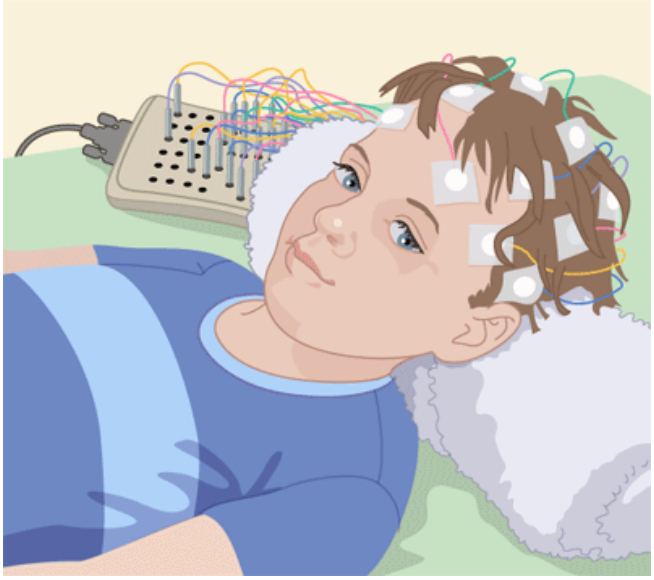
doctor may recommend that our child stop taking certain medications before the test that can alter results. It's often recommended that kids avoid caffeine up to 8 hours before the test. If it's necessary for our child to sleep during the EEG, the doctor will suggest ways to help make this easier.

The Procedure

An EEG can either be performed in an area near the doctor's office or at a hospital. Our child will be asked to lie on a bed or sit in a chair. The EEG technician will attach electrodes to different locations on the scalp using adhesive paste. Each electrode is connected to an amplifier and EEG recording machine.The electrical signals from the brain are converted into wavy lines on a computer screen. Our child will be asked to lie still because movement can alter the results.

If the goal of the EEG is to mimic or produce the problem our child is experiencing, he or she may be asked to look at a bright flickering light or breathe a certain way. The health care provider performing the EEG will know our child's medical history and will be prepared for any issues that may arise during the test.

Most EEGs take about an hour to perform. If our child is required to sleep during it, the test will take longer. We might be able to stay in the room with our child, or we can step outside to a waiting area.



What to Expect

An EEG isn't uncomfortable and patients do not feel any shocks on the scalp or elsewhere; however, having electrodes pasted to the scalp can be a little stressful for kids, as can lying still during the test.

Getting the Results

A neurologist (a doctor trained in nervous system disorders) will read and interpret the results. Though EEGs vary in complexity and duration, results are typically available in several days.

Risks

EEGs are very safe. If our child has a seizure disorder, our doctor might want to stimulate and record a seizure during the EEG. A seizure can be triggered by flashing lights or a change in breathing pattern.

3. An overview of Literature survey

3.1 The Narcoleptic Cognitive Pupillary Response

It has been reported that narcoleptics exhibit deficitsin short-term memory, list recall, and stimulus frequency estimationcompared with control subjects. It is also well-known thatpupil dilation during cognitive tasks is a measure of subject attentionstate. Narcolepticsbegin pupillary dilations at a smaller diameter, begin dilatingearlier poststimulus, attain higher pupillary diameter velocities,yet achieve the same equilibrium dilation diameter as controls.These findings are derived fromstatistical tests performed onthe parameters of a nonlinear regression model of pupillary cognitivedilation as a function of time.In case of repeated tasks at the same memory load elicita near normal naroleptic pupillary dilation.

SENSORY stimuli under fixed illumination conditions produce pupillary dilations in a wide range of species. This psycho sensory response is initiated by parasympathetic inhibitionand sympathetic excitation of the iris sphincter and dilatorpupillae, respectively, which in turn depend on inputs from forebrainstructures. Lowenstein [1] found that elevated attentionstates increase pupillary dilations. The work of Hess and Polt[2] was the first systematic study of pupillary dilation attributedto the mental effort of problem solving. Subsequent researchrelating pupillary responses to tasks of mathematics, languageprocessing, short-term memory, and pattern recognition, plusnew results, are cited by Beatty [3]. The work of Qiyhuan*et al.*[4] is particularly interesting in the area of human informationprocessing since it directly relates the uncertainty of the cognitivestimulus and maximum pupillary dilation. The maximum pupillary dilation in responseto uncertain acoustic stimuli is proportional to the Shannon informationmeasure of the stimulus, that is $\log_2 (1/p_i)$ where p_i is the stimulus probability, Shannon [5], O'Neill and Zimmerman[6]. This result finds interpretation in the findings ofSchluroff*et al.* [7] who show that more informationally complexsentences evoke greater cognitive effort and attendant increasedpupillary dilation. A major step toward quantifying thepupillary cognitive response was made by Hocks and Levelt [8]when they demonstrated that the pupillary dilation response toa cognitive (acoustic or visual) shock

represents a linear systemhaving a strictly limited output range. There is a comprehensivelydiverse mix of stimuli dating to 1966, confirms the limitedoutput range of the cognitively driven pupil: maximum dilationaveraged 0.497 mm with a standard deviation of 0.16 mm and arange 0.16 to 0.75 mm. This range is less than 8% of the pupil'stotal possible dilation range of approximately 9.5 mm [21].

As an attention disorder, narcolepsy impacts on cognitionhave been well studied (Valley and Broughton [9], Levanderand Sachs [10], Aguirre *et al.* [11], Henry *et al.* [12], andHenry *et al.* [27]) but there is no study comparing controlsand the narcoleptic pupillary dynamical response to cognitiveloading. The strongest evidence that significant differencesmight exist is the work of Henry *et al.* [27] who found thatnarcoleptics had inferior word list recall responses, inferiorword frequency estimation, and significantly longer (519 msversus 447 ms) perceptual encoding times on Sternberg [14]short-term memory visual scanning tasks. The recognition ofattentional deficit attributes of narcolepsy suggested to some(Yoss*et al.*[15], Schmidt and Fortin, [16], Hertz *et al.* [17])that pupillography would be useful for studying this and othersleeping disorders.

With the advent of computer controlled, infra-red pupillometers,it has become possible to capture pupillary dilation anomaliesonce hidden in measurement noise and, as a consequence, tomeasure the task-evoked pupillary response to small deviationsof task load. For such a study, weneed to selected the popular digit-span,short-term memory test which is a widely recognized test whoseoutcomes depend on attention level, Beatty [3]. The natural hypothesisis that narcoleptics should have different pupillary responsesfrom controls but as this response is a complex dynamicalone it is not clear how to characterize any hypothesized differences.

3.2Emotional responses as independent components in EEG.

With neuroimaging studies showing promising results fordiscrimination of affective responses, the perspectives of applyingthese to create more personalised interfaces that adaptto our preferences in real-time seems within reach. Additionallythe emergence of wireless electroencephalograph (EEG)neuroheadsets and smart phonebrain

scanners widens the possibilitiesfor this to be used in mobile settings on a consumerlevel. However the neural signatures of emotional responsesare characterized by small voltage changes that would behighly susceptible to noise if captured in a mobile context.Hypothesizing that retrieval of emotional responses in mobileusage scenarios could be enhanced through spatial filtering;we can compare a standard EEG electrode-based analysis againstan approach based on independent component analysis (ICA).By clustering scalp maps and time series responses we can identifyneural signatures that are differentially modulated whenpassively viewing neutral, pleasant and unpleasant images.While early responses can be detected from the raw EEGsignal, we identify multiple early and late ICA componentsthat are modulated by emotional content.

Many of the neuroimaging experiments that use electroencephalograph(EEG) when measuring affective responsesfrom pleasant or unpleasant images have identified two maincomponents; early posterior negativity (EPN) emerging before300ms and triggering a relative negative peak in the EEGamplitude [1], and a late positive potential (LPP) emergingafter 300ms [2]. Recent studies indicate that several event relatedpotential (ERP) components may be influenced asearly as 50-80ms by emotional words and faces [3]. After that an N1 component at 130ms, characterized by a parietalnegativity, is modulated by emotional versus neutral content,followed by the EPN occipital negativity described above.The early negativities are thought to reflect an increased allocationof attentional resources elicited in response to whatis initially perceived as salient in contrast to neutral. Subsequently,after 300ms, an initial P3 parietal component,followed by an occipital positive deflection corresponding tothe LPP described above, and a later central positivity (LCP)appear likewise to be modulated by emotional content. Thesethree positive components (P3, LPP and LCP) characterizedby shifting scalp topologies might be related to memoryencoding and further semantic processing of the emotionalcontent [4].

The promising results for distinguishing emotional responseslead to the perspective of applying these to createmore personalised content in real-time [5, 6, 7]. Additionallythe emergence of wireless electroencephalograph (EEG)neuroheadsets and smartphone brainscanners [8] widens thepossibilities for this to be used on consumer level. However,even when recording EEG under ideal conditions in alab, emotional ERP

responses are defined by only slight _Vchanges within single electrodes that would remain highlysusceptible to noise in a mobile context. An example of thiscan be seen in a recent EEG experiment using an auditoryoddball paradigm indicating that the P300 amplitudes mightbe reduced by 35% when walking compared to sitting ona chair [9]. In contrast, a similar mobile EEG experimentrecording P300 responses while standing, walking and runningshowed no difference in amplitudes [10] when applyingspatial filtering based on independent component analysisICA [11]. Although the rows in the matrix of EEG dataare initially defined by voltage differences measured overtime between each electrode and the reference channel, theyare based on ICA transformed into temporally independentevents that are spatially filtered from the channel data. While aspects of volume conduction within the brain are not takeninto consideration, the ICA decomposition frequently resultsin components that resemble neuroanatomical projections ofdipoles, which in turn reflect synchronous activity of local field potentials projected throughout the scalp [12].

Hypothesizing that retrieval of affective responses (ERPs)might be enhanced through spatial filtering, we compare astandard EEG electrode-based analysis against an approachbased on independent component analysis (ICA). In the subsequentsections we outline the experimental methods, derivedresults and discuss our findings.

4. Statement of Problem

Early interactions don't just create a context; they directly affect the way that the brain is 'wired'. Early experiences have a decisive impact on the architecture of the brain, and on the nature and extent of adult capabilities. Brain development is non-linear: there are prime times for acquiring different kinds of knowledge and skills. To analyze brain scientifically in children in developing countries like India, and to do a detailed study is the motive of the research.

Main objective of the work can be described by the statement of problem, which is expressed as follows.

"To study and do a scientific analysis of children in developing countries like India using technologies in image processing and affective computing."

The proposed research work can be divided into following steps:

1. Analyze children learning capabilities by capturing images and studying the pupil dilation of the same when children are given some task/activity.
2. To growth through the EEG parameters of children and do a detailed analysis.
3. To analyze other feasible medical parameters like blood pressure, heart rate, etc. when children are given a task or performing activities.
4. Analyzing stress levels of students when increasing the difficulty levels.

5. Implementation

This work has been planned to study and perform a detailed analysis of children under standard experimental condition by capturing images, various feasible scientific parameters using various image processing and affective computing techniques.

A tentative time schedule of the research work planned is given below –

Sr. no.	Research activity	Schedule
1.	Further detailed literature survey	July 2016 to Oct 2016
2.	Capturing images, analyzing/processing images	Nov 2016 to Feb 2017
3.	Studying and analyzing results	March 2017 to June 2017
4.	Working with EEG, capturing data & analysis	July 2017 to Nov 2017
5.	Working together with image and EEG	Dec 2017 to March 2018
6.	Study and analyzing results	April 2018 to July 2018
7.	Performance evaluation	Aug 2018 to Nov 2018
8.	Thesis write-up, revision and correction	Dec 2018 to June 2019

6. Conclusion

By this research we analyze the brain development of children in developing countries like India using the technologies of image and affective computing.We shall accomplish the task by various experiments and data collection like image, EEG parameters, heart rate, blood pressure and performing a detailed study on the data.

7. References

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